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Final Report Contract No. 956632

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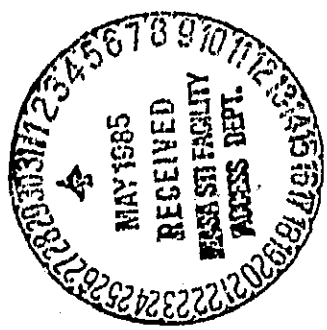

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ABSTRACT

This is the final report of the contract No. 956632 of the Jet Propulsion Laboratory, California Institute of Technology, for the development of a persistant chemical agent simulation system. This PCASS is to be used for the military training of troops to simulate actual chemical warfare. The purpose of our system is to facilitate in the determination of chemical contamination and effectiveness of decontamination for training purposes. The fluorescent tracer employed has no daylight activation, but yet is easily removed with a decontaminate solution or water and surfactants. Also employed is a time delayed color developing system. When an individual is subjected to the PCASS and does not decontaminate adequately, red blotches or red coloration will develop as a function of time and temperature. The intent of this is to simulate the delayed chemical reaction of mustard contaminates.

INTRODUCTION

The development of the Angstrom PCASS system has used non-toxic materials which should act as persistant chemical agents under a simulated battlefield condition. The decon agents that Angstrom has developed will simulate the actual decontamination agents such as DS2 or STB used in field training. Angstrom has also provided a fluorescent black light (battery-powered) to be used by the training officer to detect the presence of the simulant which is otherwise non-visible to the casual observer. Angstrom has used the M8 and the M9 detector papers as part of the system so that our PCASS system, which should aid the training officer in the location and detection of the PCASS in the surrounding envirnomental areas. It is Angstrom's belief that we have met all the mandatory requirements of the PCASS under the functional requirements as specified by JPL.

We realize that there are at least two areas that additional work may be performed in, one being that our PCASS is easily removed from equipment and personnel, and it is our understanding that in real life situations the actual contaminates are more difficult to remove. The second area is in the PCASS with the garlic oder we realize we have a high concentration of garlic and could reduce this level to whatever level is desired as well as change the odor to that of wild onions or mustard, if desired by JPL.

TECHNICAL DISCUSSION

The formulation for PCASS No. 1 has a flourescent compound in a visco-elastic base; 64.25% by weight of water, 25.0% of Isopropanol (Anhydrous), 10.0% of Di-ethly amino ethanol, 0.5% Angstrom Scanning Compound No. 6, 0.25% of Celanese Polyhall 500. Formulation of PCASS No. 2, flourescent and color developing with garlic odor: 62.73% by weight of water, 25.0% Isopropanol (Anhydrous) 10.0% Di-ethyl amino ethanol, 1.5% Angstrom Resisto Red, 0.5% Angstrom SC-4, 0.25% Celanese Polyhall 500, 0.02% oil of garlic. The formulation and processing of the PCASS No. 1 and PCASS No. 2 are as follows:

In a suitable sized container add the Isopropyl alcohol with the Di-ethyl amino ethanol, dissolve the Celanese Polyhall 500 and slurry in the appropriate scanning compound (in PCASS No. 2 slurry in the Angstrom Resisto Red also). After a good slurry has been obtained, and the Celanese Polyhall 500 is dissolved, slowly add the water with very gentle stirring. High sheer agitation or high speed mixing will break down the visco-elastic properties of the Celanese Polyhall.

Both PCASS No. 1 and PCASS No. 2 can be atomized and sprayed using, 40 lbs. force per square inch guage air supply. The decontamination simulants can also be sprayed from a household plant or laundry water spray. With the flourescent black light the trainer can detect the presence or absence of both PCASS No. 1 and PCASS No.2.

Both PCASS simulants when put on aluminum foil with a 5 ml. drop will shrink to approximately 2 ml. after 8 hours exposure at 80^0F with 50% relative humidity. This was tested in a controlled environmental chamber, where the relative humidity was maintained at 49 + 2% and 80^0F. Both PCASS's will allow the reuse of the training area after a period of 16 hours on a non-interfering basis. The flourescence will remain, the dye will develop to a red color but neither compound will cause a development on the M8 or M9 paper.

The PCASS, both 1 and 2, can be used over a wide temperature range and humidity conditions. We have tested it to a minus 7^0C without any freezing of the material, as the temperature lowers the time development colorant will take longer to develop, as the temperature increases the time development colorant will take a shorter period of time to develop.

PCASS No. 1 has a visco-elastic property which was accomplished by using the Polyhall 500 from Celanese (a polyacrylamide compound). PCASS No. 2 has a characteristic smell of garlic and a yellowish orange coloration. The garlic odor was provided with oil of garlic and could be changed to a wild onion odor or any other odor desired, as well as the concentration could be increased or decreased depending on JPL's requirements. The PCASS No. 2 has the latent chemical

developer. This will cause a red coloration upon exposure on the skin or air exposure to the droplet. The detection on the Army M8 and M9 paper was formulated using the Isopropyl alcohol and the di-ethyl amino ethanol. On the M9 paper from one to five minutes, at the spot of contamination, there should be a thin criminson line developing, on the M8 paper a color change will occur that will give a green or darkening color. The decontamination simulants are surfactants; we have formulated our PCASS systems to be water miscible and water soluable. In both cases our decons are shampoo and soap formulations with concentrations that should be let down with 50 parts water to 1 part of our decon.

The thickening of the material to make it appear like STB can be made thicker, it can be made more opaque with the addition of a pearlescent type of additive that is normally used in shampoos, if a thicker or more opaque decontamination simulant is desired by JPL. The PCASS can be thermally decontaminated to the point that it will not give a positive reaction on the M9 and M8 papers. But in the thermal decontamination procedure, water and a surfactant must be added in the exhaust gas stream to achieve adequate results, in order to achieve total decontamination of the PCASS 1 and PCASS 2.

Under trainer detection, we are using the hand held battery powered black light for the trainer to determine improper decontamination. After the eighth hour, we will not get a result on the M8 and M9 detector papers. Also the PCASS does not have a visible fluorescent activity. We feel this is an advantage in the field and during training excerises, daylight fluorescence would give false feelings of security to the individuals going through the training excerise. They could visually locate contaminated areas due to the daylight fluorescent.

Under separate cover we are sending to JPL the reakdown of the Scanning Compound 4, Scanning Compound 6, and the environmental impact of each of the separate components. This will be sent to JPL by certified mail, attention Kathy O'Hara, within ten days. We have completed preliminary cost evaluation on the PCASS. Both PCASS 1 and 2 can be formulated between $2.50 to $4.00 per gallon in field use quantities. It is Angstrom's opinion that the inherent personnel, equipment, and environmental safety of our PCASS is that of being innocuous and that no apparent dangerous conditions exist. The storage of the intermediates going into our PCASS is that of normal warehouse storage and should be kept above freezing, not to exceed 100°F. The flashpoint of the final PCASS is 85°F under a tag closed cup test.

BACKGROUND FORMULATION DATA

Angstrom in the development of the PCASS 1 and 2 have evaluated a large number of Thixotropic compounds and different vehicles with varying results. The following is an account of the items that were investigated. Of note, the item that appears to be very significant was the development and use of Polyhall 500. We initially used the acrysols (Rohm Haas) to cause a thickening of the PCASS. However, on evaporation of the material, we did not reduce the size of the droplets during an eight hour period at 80°F and 50% relative humidity, but we merely shrunk the total thickness down. We observed a skinning or a film deposition of the acrylic polymers as it would dry out. We abandoned the use of the acrysols because it was too hard to remove from cloth and metal and went to the Polyhall 500 which gives us both the thickening and elastic properties as well as the water miscibility. The following is a breakdown of the experiments and the results we got:

EXPERIMENT 1

Dow Methocel F-50-LV	2 grams
Polyethylene Glycol 400	20 grams
Wetted and stirred out well	
Cold Tap water	60 grams
Small exotherm	
Stirred out to slurry	
Anhydrous Ethanol	20 grams
Stirred out and refrigerated	
Moderately viscous solution	

EXPERIMENT 2

Methylethyl Ketone	5 grams
Methylisobutyl Ketone	5 grams
Glycerol	10 grams
Polyethylene Glycol 400	30 grams
Stirred out	
good yellow on M-8 paper	
good red on M-9 paper	

Experiment 1 and Experiment 2 put on aluminum foil both gave inadequate results. Experiment 1 filmed over. Experiment 2 did not evaporate well.

EXPERIMENT 3

Fisher B-235 Bentonite Clay	5 grams
Water	100 grams
Too thin, scrapped	

Bentonite would leave a visible tracing upon observation after 16 hours.

EXPERIMENT 4

Tall Oil Fatty Acid Sylfat #496 (Emery)	10 grams
Hot water	190 grams
NaOH pellets to ph 10	
Boiled and cooled -- too thin	
Some material preciptated	
Scrapped	

Repeated with Emery EMPOL 1003-B Dimer
Too thin, scrapped.

EXPERIMENT 5

Dioxane/Water
Dioxane neat -- good red on M-8 & M-9
50% Dioxane -- good red on M-8 & M-9
25% Dioxane -- good red on M-9, faint on M-8
12½% Dioxane -- slow on M-9, nil on M-8

Dioxane/water solution - scrapped
Di-ethyl amino ethanol much better result

EXPERIMENT 6

Hot water	190 grams
C-1469 Glue Gel, Fuller	20 grams

High viscosity
Cooled - thin solution,
scrapped

EXPERIMENT 7

Hot water	200 grams
"Bacto" Agar	1 gram

Heated and stirred to a boil
Clear solution
Soft gel at 30°C
Added 12.5 ml. Dioxane to 37.5 ml. solution
Gel - scrapped

EXPERIMENT 8

Carbopol 940	1 gram
Dioxane	50 ml.

Swelled, did not disperse well

Hot water	50 grams

Put on tissue homogenizer
Did not break up satisfactorily
Neutralized to ph 7 with
Di-ethyl amino ethanol
Too thin, scrapped

EXPERIMENT 9

Polyethylene Glycol 200	10 grams
Polyhall 500	.03 grams

Slurried with spatula

Water	10 grams

Stirred with spatula to an elastic goo

P.E. Glycol 200	80 grams

Incomplete solution
Scrapped

EXPERIMENT 10

Carbopol 940	2 grams
Dioxane 50 ml.	
Slurried	
Water	150 ml.
Slurried	
Mono-ethanolamine to ph 7	8 ml.
Too thin - scrapped	

EXPERIMENT 11

To set up a controlled viscosity standard

Gelamide 250	1 gram
PE Glycol 200	50 grams
Slurried	
Water	50 grams
Dissolved well	
Gave the visco-elastic standard, sprayed well	
formed correct droplet size,	
problem - would not evaporate accordingly	
Added IPA, fast evaporator	
nor would give good indication on M-8 & M-9 paper	
but did form visco-elastic standard.	

EXPERIMENT 12

Polyhall 500	1 gram
Dioxane	25 ml.
Slurry	
Water	75 ml.
Dissolved well, viscosity good	
M-9 color, indifferent	
Maybe contamination on M-9 paper	

EXPERIMENT 13

Viscosity Standard	100 grams
measured viscosity on Brookfield	
to 113 cps @ 25^{0}C	

EXPERIMENT 14

Polyhall 500	1 gram
9.9% Isopropanol	100 grams
Slurry	
Water	100 grams
Stirred till smooth with spatula	
Amino ethanol	1.5 ml.
Weak test on M-9	
Fair test on M-8	
Viscosity - 144 cps @ 25^{0}C	

EXPERIMENT 15

Water	40 ml.
99% Isopropanol	50 ml.
M.E. Ketone	12.5 ml.
M.I.B. Ketone	12.5 ml.
Weak tests on M-8 & M-9 papers	
Amino ethanol	1.5 ml.
Good test on M-8, Nil on M-9	
Resin did not dissolve - scrapped	

EXPERIMENT 16

99% Isopropanol alcohol	62.5 ml.
Polyhall 500	1 gram
M.E. Ketone	25 ml.
Amino ethanol	2 ml.
Slurry	
Water	127 ml.
Dissolved well	
Good color on M-8, Nil on M-9	
Viscosity 101 cps @ 25^0C	

EXPERIMENT 17

Water	127 ml.
99% Isopropanol	62.5 ml.
Di-ethyl amino ethanol	5 grams
Good test on M-8, Nil on M-9	

EXPERIMENT 18

Isopropanol	62.5 ml.
Di-ethyl amino ethanol	20 grams
Polyhall 500	1 gram
Slurry	
Water	130 ml.
Dissolved well	
Good color on M-8 & M-9	
16 hour test in controlled humidity	
50% relative humidity at 80^0F	
Negative test on both papers	
8 hour test weak on wet M-8, Nil on M-9	
viscosity @ 25^0C was 600 cps	
Diluted previous experiment	
99% Isopropanol alcohol	31.25 ml.
Water	65 ml.
Di-ethyl amino ethanol	10 grams
Previous experiment	100 grams
Viscosity 238 cps @ 25^0C	
Refrigerated at 15^0C	
Liquid after 2 hours	

EXPERIMENT 19

Odor Tests

Water	520 ml.
99% Isopropanol	250 ml.
Di-ethyl amino ethanol	80 grams

To 100 ml. portions,
add 1 gram each
Cino garlic Replacement WONF 83571
Cino Onion Replacement 38402
Cino Garlic Flavor WONF 5:1
Cino Onion Flavor WONF 5:1
Slurried
Stand overnight

Best result Cino Garlic Flavor 5:1

EXPERIMENT 20

Angstrom Resisto Red time delay colorant

99% Isopropanol	62.5 ml.
Polyhall 500	0.5 grams
Di-ethyl amino ethanol	20 grams
Angstrom Resisto Red	1 gram

Slurried thoroughly

Water	126 ml.

Agitated to a complete solution
Latent color development on M-8 & M-9
Color development overnight
Strong red color upon heating

EXPERIMENT 21

Previous experiment
added

Scanning Compound 4	1 gram

Good Flourescent indication
as well as previous results

EXPERIMENT 22

Tried to increase the amount of color developer

Levels tested	0.5%
	1.0
	1.5
	2.0
	2.5

Found 1.5% by weight appears to be the limit of solubility.

EXPERIMENT 23 (11-14-83)

Prepared final solution of 50 lbs. PCASS 1

99% Isopropanol	12.5 lb.s
Polyhall 500	57 grams
Slurry with spatula	
Di-ethyl amino ethanol	5.0 lbs.
Stirred out	
Angstrom Scanning Compound 6	113 grams
Slurry	
Water	32 lbs. 2 oz.
Gradually stirred with agitation until thick	
SC 6 was agglomerated	
Corrected with homogenizer	

PCASS 2

99% Isopropanol	12.5 lbs.
Polyhall 500	57 grams
Slurry with spatula	
Di-ethyl amino ethanol	5.0 lbs.
Stirred out	
Angstrom Resisto Red Powder	339 grams
Slurried thoroughly	
Scanning Compound 4	113 grams
Slurried	
Water	31 lbs. 6 oz.
Scanning Compound 4 agglomerated	
Corrected by homogenizer	
Pure garlic oil food grade	5 ml.
to give odor	
Pack out into containers	

Decontaminates

#1

Emery 5320 Laureth Sulfosuccinate	30 percent
Emery Emid 6511 - Di-ethanolaminolauramide	5 percent
Emery 5430 Cocoamidopropylbetaine	3 percent
Emery Lanoquat 1756	1 percent
Emerest 2350 Glycol Stearate	1 percent
Emeressence 1160 Phenoxyethanol	1 percent
D.I. Water	59 percent

#2

Emery 6434 Triethanolamine Lauryl Sulfate	50 percent
D.I. Water	50 percent

CONCLUSION-RECOMMENDATIONS

Angstrom has completed considerable investigative research into the development of the PCASS 1 and 2 along with the decontaminate solutions. Angstrom feels that the PCASS 1 and 2, and decontaminate solutions meet the functional requirements of Contract 956632. Additional work could be accomplished: the thickening of the decontaminate solution to better approximate the STB slurry, the possiblity of self quenching the fluorescent activity, and the changing of the red coloration time development formula to a yellow coloration time development formula or perhaps a blending of a red and a yellow so that we would have a higher contrast ratio on skin development on all people. Angstrom awaits any further discussion from JPL on this work.

Sincerely,

Wm. G. McGinness

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EXHIBIT A

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr / Pasadena, Calif 91103

PROPERTY CLOSE-OUT CERTIFICATE

DATE November 14, 1983

The undersigned Contractor, having completed the work called for by Contract No. 956632, dated 8-19-83, with the California Institute of Technology, Jet Propulsion Laboratory, a subcontract under NASA Prime Contract NAS7-100, hereby certifies that:

(Check one as appropriate)

☒ He and his subcontractors have disposed of all Government property as defined in NASA PR 13.101-2, and any generated scrap, in accordance with the terms of the Contract.

☐ No Government property was furnished to or acquired by the undersigned contractor or his subcontractors, nor was any scrap generated.

Angstrom Robotics & Technologies, In
Contractor

William McTamaney
Authorized Representative Signature

President
Title